06-01-00

PATENT APPLICATION TRANSMITTAL LETTER (Large Entity)	Docket No. INTL-0361-US (P8580)

TO THE ASSISTANT COMMISSIONER FOR PATENTS

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For: **POWER MANAGEMENT FOR PROCESSOR-BASED APPLIANCES**
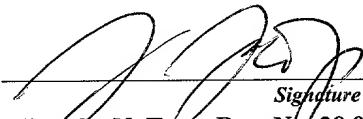
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APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: POWER MANAGEMENT FOR PROCESSOR-BASED
              APPLIANCES

INVENTORS: ANIRUDDHA P. JOSHI, CHAD W. MERCER and
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Express Mail No.: EL542038147US

Date: May 31, 2000

POWER MANAGEMENT FOR PROCESSOR-BASED APPLIANCES

Background

This invention relates generally to processor-based appliances such as set-top boxes and particularly to power management for such devices.

5   Some processor-based systems are intended to operate as appliances. Consumers may believe that appliances should operate with certain characteristics. For one, when an appliance is turned on, it should immediately operate. To some degree this is inconsistent with the way many

10   processor-based systems operate. In those systems, when the device is turned on, a boot process must be undertaken before the device is ready to operate. This delay in "active on" operation may create, for many consumers, the conception that such processor-based systems are not as

15   easy to use as an appliance. The consumer may prefer electronic devices that operate in the fashion the consumer is accustomed to with other appliances.

     A set-top box is a processor-based appliance that operates with a conventional television receiver. For

20   example, the set-top box may sit atop a conventional television receiver. The set-top box may provide computer functionality, such as Internet access, as well as control over the television. For example, the set-top box may

provide an electronic programming guide (EPG) to facilitate the operation of the television receiver. Conventionally, the television receiver acts as the monitor for computer operations as well.

5   The set-top box bridges television and computer functionalities. It is desirable that the set-top box act like other appliances such as a television receiver.

Thus, there is a need for ways to make processor-based appliances operate in a fashion similar to other

10   appliances.

Brief Description of the Drawings

Figure 1 is a front elevational view of one embodiment of the present invention;

Figure 2 is a state diagram for the embodiment of the

15   present invention shown in Figure 1;

Figure 3 shows the operation of the power management software module in accordance with one embodiment of the present invention;

Figure 3A is a flow chart for the software shown in

20   Figure 3 in accordance with one embodiment of the present invention; and

Figure 4 is a block diagram of the system depicted in Figure 1 in accordance with one embodiment of the present invention.

<u>Detailed Description</u>

A processor-based system 10, shown in Figure 1, may include a display such as a television receiver 12 and a computer such as a set-top box 14, in accordance with one

5 embodiment of the present invention. The set-top box 14 and the receiver 12 may both be operated using a remote control unit 16. The remote control unit 16 may include a power button 19 in one embodiment of the present invention. Similarly, the set-top box 14 may include a power button 13

10 in accordance with one embodiment of the present invention.

The set-top box 14 also includes an interface 22 that operates with an interface 24 on the remote control unit 16. The interface 24 on the remote control unit 16 also operates an interface 20 on the television receiver 12.

15 Thus, in one embodiment of the present invention, the interface 24 may be an infrared interface that operates infrared interfaces 20 and 22 on the television receiver 12 and the set-top box 14 respectively.

The remote control unit 16 also includes cursor

20 control buttons 26 that enable the remote control unit 16 to provide mouse-like functions. Control buttons 28 on the remote control unit 16 enable the selection of television channels and other operations.

The set-top box 14 may also include a pair of sensors

25 15 and 17. The light sensor 15 may be a light detector that detects the amount of light in the surrounding area.

3

For example, if the television receiver 12 is on, it may produce sufficient light to actuate the light sensor 15 in one embodiment. Similarly, a motion sensor 17 provided on the set-top box 14 detects motion in the surrounding area.

In one embodiment of the present invention, the set-top box 14 is normally maintained in a powered up state. That is, after the initial powering on of the set-top box 14, it is intended that the set-top box 14 may never be powered off again. Thus, electrical power may be supplied to the set-top box 14 at all times so that the set-top box 14 may never truly turn completely off after being plugged into an electrical outlet.

Referring to Figure 2, a state diagram for the set-top box 14 includes an "off" state 30, a "standby" state 34, an "on" state 36 and a "sleep" state 32. Before the set-top box 14 is plugged into an electrical outlet, it is in the off state 30. After it is plugged in, power is applied, as indicated by the arrow 38 and the set-top box 14 enters the standby state 34. In the standby state 34, the set-top box 14 maintains all its settings and is able to operate quickly in response to a user command. However, in the standby state 34 the set-top box 14 may be in a reduced or lower power consumption state relative to the on state 36. In an embodiment conforming to the Advanced Configuration and Power Interface (ACPI) Specification, Revision 1.0, December 22, 1996, the standby state 34 may be ACPI global

4

system state G1, the on state 36 may be ACPI global system state G0, and the sleep state 32 may be ACPI global system state G2.

In an embodiment in which the sleep state 32 is
5   implemented in accordance with the ACPI G2 or soft off state, the set-top box 14 consumes a minimal amount of power. No user mode or system mode code is run. The G2 state generally requires a large latency in order to return to the G0 or working state. The set-top box's context may
10   not be preserved by the hardware.

In an embodiment in which the standby state 34 is implemented in accordance with the ACPI G1 or sleeping state, the set-top box 14 consumes a smaller amount of power than in the G0 or working state, user mode threads
15   are not executed, and the set-top box 14 appears to be off from the user's perspective because the display is off. Latency for returning to the G0 or working state varies according to the wake up environment selected prior to entry into this state. Work can be resumed without
20   rebooting the operating system because large elements of system context are saved by the hardware and the system software.

In an embodiment in which the on state 36 is implemented in accordance with the ACPI G0 or working
25   state, the set-top box 14 dispatches user mode application threads and may execute instructions. Peripheral devices

may have their power states dynamically changed. The user
may select various performance/power characteristics and
may optimize software for performance or battery life. The
set-top box 14 responds to external events in real time.

5   As soon as the user presses the power button 19 on the
remote control or the power button 13 on the set-top box
14, the system 10 immediately transitions to the on state
36 as indicated by the arrow 40. This is different than
conventional processor-based systems in that operation of a

10   power button 13 or 19 does not apply power to the set-top
box 14, but instead transitions the set-top box 14 from the
standby state 34 to the on state 36. Thus, as described
above, absent unplugging the set-top box 14 from the wall
plug, power is always applied.

15   When the user operates a power button 13 or 19 again,
either through the remote control unit 16 or on the set-top
box 14, the set-top box 14 resumes the standby state 34 as
indicated by the arrow 42. If at any time, power is
removed from the set-top box 14 by unplugging it from the

20   wall plug, the set-top box 14 immediately returns to the
off state 30, as indicated by the arrow 48.

        In some embodiments of the present invention, the
sleep state 32 is not used. However, in an embodiment with
the sleep state 32, if the set-top box 14 remains in the

25   standby state 34 for a sufficiently long period of time, it
may transition to the sleep state 32 as indicated by the

arrow 44. However, if activity is detected, as indicated
by the arrow 46, the set-top box 14 immediately returns to
the standby state 34.

In the sleep state 32, the set-top box 14 may be in an
even lower power consumption state than in the standby
state 34. When in the sleep state 32, the set-top box 14
may be unable to immediately return to the fully
operational state. That is, a time delay may be required
to transition from the sleep state 32 to the standby state
34 and then on to the on state 36. The transition from the
sleep state 32 to the on state 36 may take more time than
the transition from the standby state 34 to the on state 36
in one embodiment.

It may be undesirable for the set-top box 14 to place
the television receiver 12 in a powered down state. The
user may want to watch the television receiver 12 without
using any of the set-top box 14 functions. The mere fact
that no activity is occurring on the set-top box 14 does
not necessarily suggest that the user is not actively using
the television receiver 12.

In embodiments using the sleep state 32, to prevent
extended operation in the sleep state 32, a pair of sensors
15 and 17 may be provided. If the surroundings are
sufficiently bright, as detected by the light sensor 15,
the set-top box 14 immediately transitions from the sleep
state 32 to the standby state 34. The light sensor 15 may

7

be set so that the light produced by the television receiver 12 is sufficient to cause the transition from the sleep state 32 to the standby state 34. Similarly, if it is not dark in the surrounding room, the set-top box 14 may

5   transition out of the sleep mode 32 in one embodiment. Furthermore, if activity is detected in the surrounding room through the motion sensor 17, the set-top box 14 is promptly returned to the standby state 34 in one embodiment.

10   Through the use of the sensors 15 and 17, the set-top box 14 may conserve electrical power while at the same time providing the consumer with an appliance-like operation. In some embodiments, the set-top box 14 may return to the standby state 34 before the user gets sufficiently close to

15   either the remote control unit 16 or the set-top box 14 to operate a power button 13 or 19. Therefore, in most cases, the user may not see any delay in assuming the on state 36 in response to a power button 13 or 19 operation, in some embodiments of the present invention.

20   To maintain the context when transitioning from the standby state 34 to the sleep state 32, the context may be written to a non-volatile memory prior to entering the sleep state 32. The context includes all the settings which enable the system to return to the exact screen

25   display and the same point in any application programs that

were operative. If a non-volatile memory is not available, the transition to the sleep state 32 may be avoided.

Turning next to Figure 3, a power management module 50 implements the state transitions shown in Figure 2 in accordance with one embodiment of the present invention. The power management module 50 detects a power management event (PME). A power management event may be the operation of a power button 19 or 13 on the remote control unit 16 or the set-top box 14 respectively. A power management event may also arise from a wake-up or Local Area Network (LAN) event that occurs in connection with a cable modem.

Power management events may also be generated, for example, by a conventional south bridge (such as the south bridge 76 in Figure 4). In one embodiment of the present invention, the south bridge 76 is the 82371AB PCI ISA IDE Xcelerator (PIIX4) available from Intel Corporation. The PIIX4 includes power management firmware including registers that may be set to effectuate the functions determined by power management module 50.

The power management module 50 may be part of the operating system, at the kernel level for example or a part of the boot loader as another example. Therefore, when the set-top box 14 is in any state other then the off state 30 and a power management event occurs, the power management module 50 is notified. The module 50 then passes system control to the boot loader 52. The boot loader 52 may put

the set-top box 14 into the standby state 34 by initializing the appropriate PIIX4 power management registers in one embodiment.

If the set-top box 14 is in the standby state 34 and a
5   PME event occurs, the system wakes up to the boot loader 52. The boot loader 52 returns control to the module 50 that in turn passes control back to the operating system. Thus, the set-top box 14 may resume in the on state 36, at the settings where it last left off before entering the
10   standby state 34. In particular, this means maintaining all the settings and states that existed when the standby state 34 was entered. If the user was active in a given software program before a PME event, the set-top box 14 may resume with all the states and conditions that last existed
15   and with the exact same television receiver 12 screen display.

Referring to Figure 3A, the software 50 initially assumes a standby state as indicated by the block 90. That is, as soon as power is applied, the system assumes the
20   standby state 34. At diamond 92 a check determines whether a power button has been operated. If so, the software 50 transitions to the on state 36 as indicated in block 94. Next, a check at diamond 96 determines whether the power button has been again actuated. If so, the system
25   transitions back to the standby state 34 at block 90.

10

Otherwise, the software 50 recycles and is maintained in the on state through the operation of block 94.

If in diamond 92 it is determined that the power button has not been operated, a check at diamond 98 determines whether a time out 44 has occurred. If a time out 44 has occurred, the software 50 assumes the sleep state 32 as indicated by block 100. At diamond 102 a check determines whether activity has been identified. Activity 46 may include detection of a light source or motion proximate to the system 10. If so, the software 50 resumes the standby state 34 via block 90. Otherwise, the software 50 is maintained in the sleep state 32.

Turning to Figure 4, the system 10 includes a processor 54 coupled to a host bus 56 which in turn is coupled to a host bridge 58, an accelerated graphics port (AGP) bus 62 and a graphics device 64, in one embodiment of the invention. The main memory 60 may be coupled to a system management (SM) bus 74. The graphics device 64 receives video inputs and provides outputs to a television receiver 12 through an encoder 66. The graphics device 64 receives information from a graphics local memory 68. The video inputs may include television broadcasts and videocassette recorder (VCR) inputs as well as digital videodisk (DVD) information.

The host bridge 58 is coupled to a bus 70 that may receive a plurality of peripheral devices in slots 72. The

bus 70 may also be coupled to a bus-to-bus or south bridge 76 that couples still another bus 78. In one embodiment of the present invention, the bridge 76 is the PIIX4 bridge available from Intel Corporation. The bus 78 may also

5   include peripheral device receiving slots 80.

The bridge 76 may be coupled to the motion sensor 17 and the light sensor 15. In one embodiment of the present invention, the general purpose input/output (GP[I,O]) pins available with the PIIX4 bridge may be utilized to handle

10   the signals received from the sensors 15 and 17.

The bus 78 may be coupled to the system basic input/output system (BIOS) 82 and a serial input/output (SIO) device 84. The device 84 may be in turn coupled to the interface 22 that may be an infrared interface in one

15   embodiment of the present invention.

While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended

20   claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is:

12

1   1.   A method comprising:

2   in response to operation of a power button,

3   transitioning a processor-based system from a lower power

4   consumption state to a higher power consumption state; and

5   in response to re-operation of said power button,

6   transitioning said processor-based system from said higher

7   power consumption state to said lower power consumption

8   state.

1   2.   The method of claim 1 including transitioning

2   said processor-based system from the lower power

3   consumption state to a still lower power consumption state

4   in response to a lack of activity on said processor-based

5   system.

1   3.   The method of claim 2 including transitioning

2   said system from said still lower power consumption state

3   back to said lower power consumption state if activity is

4   detected around said processor-based system.

1   4.   The method of claim 3 including detecting motion

2   around said processor-based system.

1   5.   The method of claim 2 including transitioning

2   said system from said still lower power consumption state

13

3   back to said lower power consumption state if light is

4   detected around said processor-based system.

1   6.   The method of claim 1 wherein said processor-

2   based system includes a television receiver, said method

3   including transitioning from said still lower power

4   consumption state to said lower power consumption state

5   whenever said television receiver is operating.

1   7.   The method of claim 1 including preventing said

2   system from going to a power off state in response to

3   operation of a power button.

1   8.   The method of claim 1 including receiving a power

2   command from a power button on a remote control unit.

1   9.   The method of claim 1 wherein said system

2   includes an operating system, said method including

3   providing a power management module in connection with the

4   operating system for said processor-based system to handle

5   power management events.

1   10.   The method of claim 9 wherein said power

2   management module responds to power management events by

3   passing control to a boot loader.

14

1   11.   An article comprising a medium that stores

2   instructions that cause a processor-based system to:

3   in response to operation of a power button,

4   transition said processor-based system from a lower power

5   consumption state to a higher power consumption state; and

6   in response to re-operation of said power button,

7   transition said processor-based system from said high power

8   consumption state to said lower power consumption state.

1   12.   The article of claim 11 further storing

2   instructions that cause a processor-based system to

3   transition from the lower power consumption state to a

4   still lower power consumption state in response to a lack

5   of activity on said system.

1   13.   The article of claim 12 further storing

2   instructions that cause a processor-based system to

3   transition from said still lower power consumption state

4   back to said lower power consumption state if activity is

5   detected around said processor-based system.

1   14.   The article of claim 13 further storing

2   instructions that cause a processor-based system to detect

3   motion around said processor-based system.

15

1   15.   The article of claim 12 further storing
2   instructions that cause a processor-based system to
3   transition from said still lower power consumption state
4   back to said lower power consumption state if light is
5   detected around said processor-based system.

1   16.   The article of claim 11 further storing
2   instructions that cause a processor-based system to
3   transition from said still lower power consumption state to
4   said lower power consumption state in response to operation
5   of a television receiver.

1   17.   The article of claim 11 further storing
2   instructions that prevent said system from going to a power
3   off state in response to operation of a power button.

1   18.   The article of claim 11 further storing
2   instructions that cause said processor-based system to
3   receive a power on command from the power button on a
4   remote control unit.

1   19.   The article of claim 11 further storing
2   instructions that cause a processor-based system to
3   transition between said lower and higher power consumption
4   states using a software module at the operating system
5   kernel level.

1   20. The article of claim 19 further storing

2 instructions that cause said processor-based system to

3 respond to power management events by passing control to a

4 boot loader.

1   21. A system comprising:

2   a processor;

3   a storage coupled to said processor;

4   a power button for said system, said power button

5 operable to cause said system to transition from a lower

6 power consumption state to a higher power consumption state

7 or to transition from said higher power consumption state

8 to said lower power consumption state.

1   22. The system of claim 21 including a housing, said

2 processor and said storage mounted in said housing and said

3 power button being mounted on said housing, said housing

4 coupled to a sensor that detects activity surrounding said
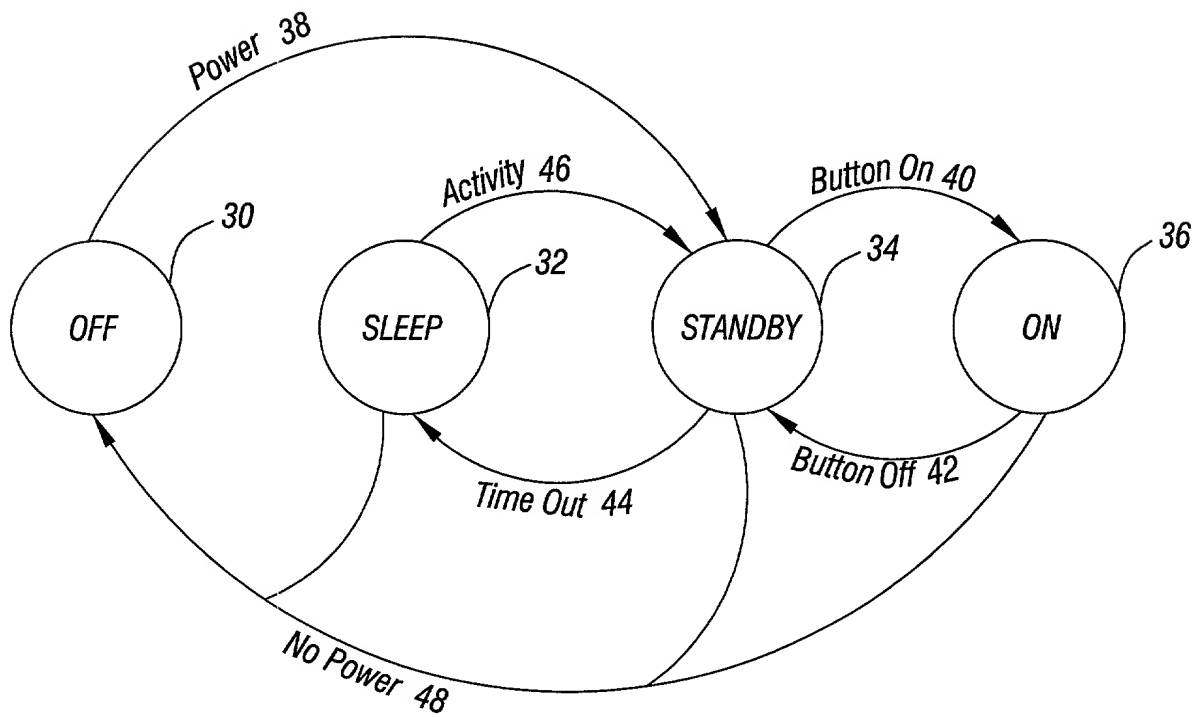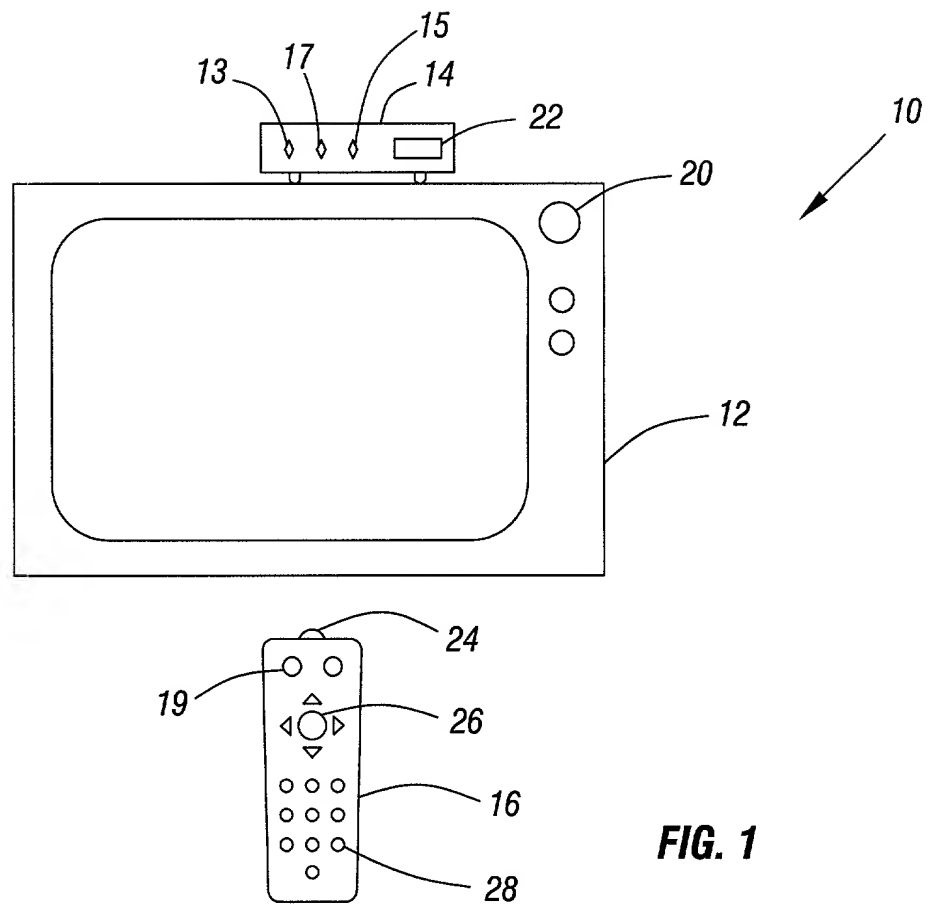
5 housing.

1   23. The system of claim 22 wherein said sensor is a
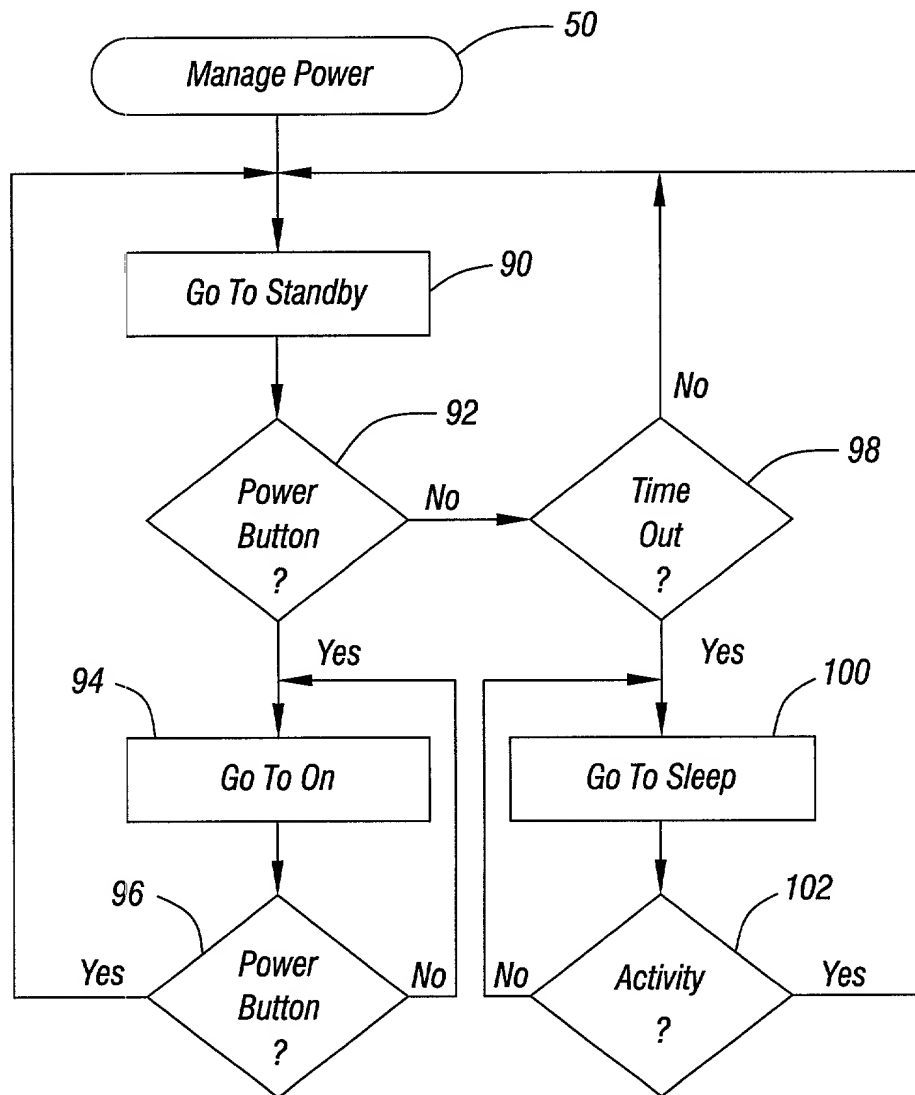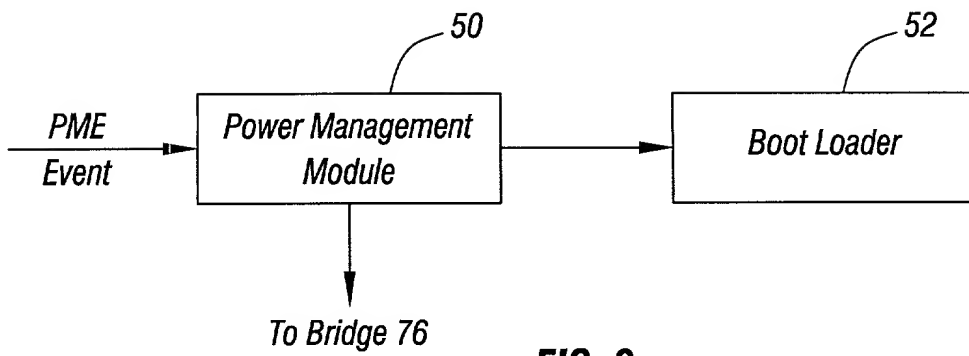
2 light sensor.

1   24. The system of claim 23 wherein said system

2 further includes a television receiver coupled to said

3   processor, and said light sensor is adapted to detect light

4   from operation of said television receiver.

1   25.   The system of claim 22 wherein said sensor is a

2   motion sensor that detects motion proximate to said

3   housing.

1   26.   The system of claim 21 wherein operation of said

2   power button does not remove power from said system.

1   27.   The system of claim 21 including a timer that

2   transitions said system to a still lower power consumption

3   state in response to system inactivity for a period of time.

1   28.   The system of claim 27 wherein said system

2   automatically transitions from said still lower power

3   consumption state in response to the detection of activity

4   proximate to said processor.

1   29.   The system of claim 21 wherein said system is a

2   set-top box.

1   30.   The system of claim 21 including a remote control

2   unit coupled to said processor, said unit including a power

3   button that transitions said system between said higher and

4   lower power consumption states.

POWER MANAGEMENT FOR PROCESSOR-BASED APPLIANCES

Abstract of the Disclosure

A processor-based system may be operated in an effectively "always on" condition. The system may transition from a lower power consumption state to a higher

5   power consumption state in response to the first operation of a power button. In response to a second operation of the power button, the system transitions from the higher power consumption state to the lower power consumption state. However, unless the system is unplugged, the system

10   remains in a power consuming state even when the power button is repeatedly operated.

19

FIG. 1

FIG. 2

PME
Event → Power Management Module → Boot Loader

50

52

To Bridge 76

FIG. 3

Manage Power — 50

Go To Standby — 90

Power Button ? — 92

No → Time Out ? — 98

No

Yes (Power Button) → Go To On — 94

Yes (Time Out) → Go To Sleep — 100

Power Button ? — 96
Yes / No

Activity ? — 102
No / Yes

FIG. 3A
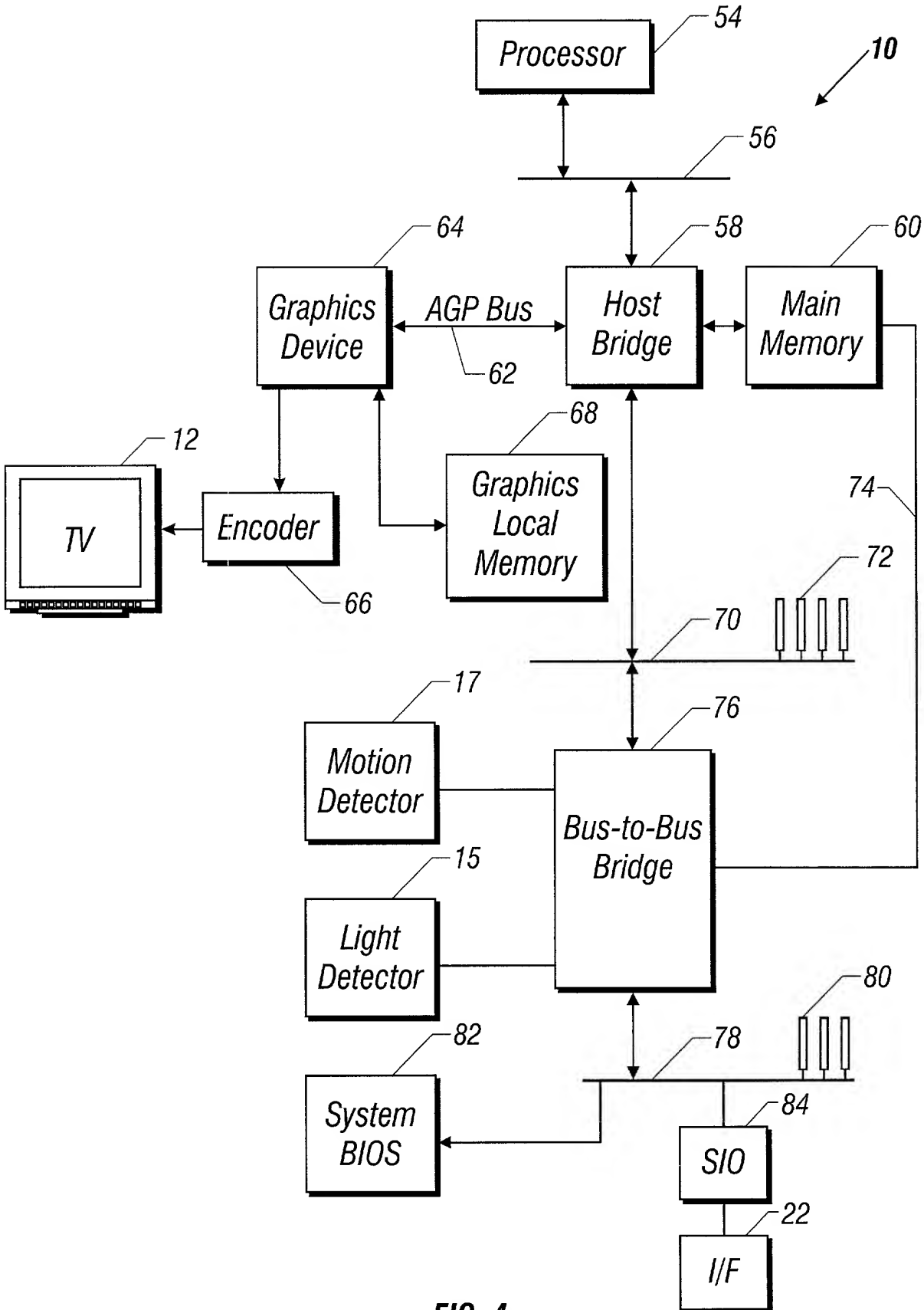
FIG. 4

<u>DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION</u>

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

POWER MANAGEMENT FOR PROCESSOR-BASED APPLIANCES

the specification of which

X	is attached hereto.
	was filed on _____ as
	United States Application Number _____
	or PCT International Application Number _____
	and was amended on _____
	(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate Issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

<u>Prior Foreign Application(s):</u>			<u>Priority Claimed</u>	
Number	(Country)	(Day/Month/Year Filed)	Yes	No
Number	(Country)	(Day/Month/Year Filed)	Yes	No
Number	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under title 35, United States Code, Section 119(e) of the United States provisional application(s) listed below:

(Application Number)	(Filing Date)

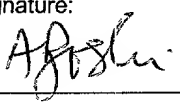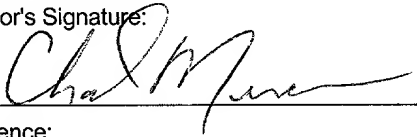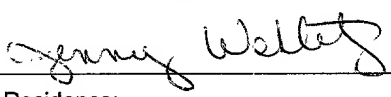|	
(Application Number)	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Number)	Filing Date	(Status-patented, pending, abandoned)

(Application Number)	Filing Date	(Status-patented, pending, abandoned)

I hereby appoint Timothy N. Trop, Reg. No. 28,994; Fred G. Pruner, Jr., Reg. No. 40,779 and Dan C. Hu, Reg. No. 40,025 my patent attorneys, of TROP, PRUNER & HU, P.C., with offices located at 8554 Katy Freeway, Ste. 100, Houston, TX 77024, telephone (713) 468-8880, and Joseph R. Bond, Reg. No. 36,458; Richard C. Calderwood, Reg. No. 35,468; Sean Fitzgerald, Reg. No. 32,027; David J. Kaplan, Reg. No. 41,105; Leo V. Novakoski, Reg. No. 37,198; Naomi Obinata, Reg. No. 39,320; Thomas C. Reynolds, Reg. No. 32,488; Steven P. Skabrat, Reg. No. 36,279; Howard A. Skaist, Reg. No. 36,008; Steven C. Stewart, Reg. No. 33,555; Raymond J. Werner, Reg. No. 34,752; and Charles K. Young, Reg. No. 39,425; my patent attorneys, of INTEL CORPORATION; with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2

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INTL-0361 -US (P8580)

3